

Respiratory System

Conducting part

- Conduct air to resp. part
- = Nose, nasopharynx, larynx, trachea, bronchi & bronchioles & terminal bronchioles.

Functions of conducting part:

1. Conduction of inspired air:
 - presence of cartilage, collagen fibres → prevent collapse → patent airway.
 - Smooth ms. & elastic fibres give → flexibility & extensibility.
2. Conditioning of inspired air [Clean, moist & warm].
 - the mucosa is mostly ps. st. col. cil. epith & goblet cells (= respiratory epith)
 - the c.t. is rich in bl. caps. serous & mucous glands.

The Nose

Formed of:

1. Vestibule:

lined e' hairy skin [hairs = vibrissae to trap dust]. It changes upwards into non-keratinized str. sq.

2. Nasal Fossae:

- 2 chambers separated by bony nasal septum
- In each fossa 3 bony projections (conchae) extend from the lat. wall
- The sup. concha: covered e' Olfactory epith. * while the middle & inf. conchae: are covered e' Resp. epith. * = ps. st. col. cil. e' goblet cells.
- The conchae: ↑↑ surface area for resp. " to → condition the air
- ↳ create turbulence of air flow.
- The underlying C.t = lamina propria.
- rich in → large plexus of veins = **Swell bodies**
- ↳ mucous glands, WBCs, macrophages & plasma cells.

* Inflammation & allergy → congestion of swell bodies of both fossae → limiting air flow.

* Epistaxis:

- = bleeding from the nose. It might start in the nose or sinuses due to injured vessels during forceful sneezing e' ↑↑ press. in the vascular nasal-septum.

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Covers the sup. concia lined & ciliated mucosa.

I. Olfactory Epith.

= modified ps. st. col. cil. epith. e' no goblet cells. Have 3 types of cells:

a). Olfactory Neurons :

= bipolar nerve cells. the dendrites : extend to surface & end in olfactory vesicles e' basal bodies from w 6-8 non-motile cilia arise to $\uparrow$ surface area for odorous substances. the nuclei : present at a level bet. nuclei of the supporting & basal cells. the axons : pass to the underlying c.t. & form the olfactory nerve w pass through the cribriform plate of ethmoid to the brain

• Function : chemoreceptor for smell.

b) Sustentacular (Supporting) Cells :

- tall col. cells e' wide apex & narrow base.
- have apical microvilli submerged in a fluid layer.
- have oval nuclei near the ~~the~~ surface.
- Cytoplasm contains yellow pigment $\rightarrow$ w give the yellow colour of mucosa
- joined to the olfactory cells by Junctional complexes.
- Function : supportive.

c) Basal Cells :

1 layer of short Δ cells e' dark rounded nuclei & basophilic cytoplasm. resting on the b.m. Function : stem cells for the other cells.

* Stem cells have high capacity to replace olfactory cells.

So, exposure to toxic fumes $\rightarrow$ temporary loss of smell

Fracture of ethmoid bone $\rightarrow$ permanent loss of smell (damage of olfactory nerve)

II. C.T. Corium = Lamina propria :

= dense c.t. rich in bl. vs., olfactory n. fs + Bowman's glands*

= tubulo-alveolar serous glands: their ducts open on the surface. their secretion acts as solvent for odorous substances.

The Respiratory Epith.

= ps. st. col. cil. e' goblet cells. Contains 5 types of cells:

1. Col. Ciliated cells : most numerous (300 cilia/cell). The apex of cells contain basal bodies & mit. $\rightarrow$ energy for ciliary beating.
2. Goblet Cells : next numerous : form & secrete mucous to trap dust & bacteria. the apex is rich in mucous granules.
3. Brush Cells : Col. cells e' apical microvilli & basal n. fs. Function: may act as receptors.
4. Basal Cells : short cells, rest on the b.m. but donot reach the surface. F. : act as stem cells for other cells.
5. Small Granule Cells : [Diffuse Neuroendocrine Cells]. Have basal granules e' dense core. Release hormones e.g. serotonin & catecholeamines w control caliber of airways & bl. vs.
 $\rightarrow$ regulate mucous & serous secretion.

* In Smokers: the ratio ciliated to goblet cells is reversed to Clean CO. the movement of mucous $\downarrow \rightarrow$ congestion of small airways

	Olfactory Mucosa	Respiratory mucosa
• Epith. thickness	- thicker	- thinner.
• Cilia	- few, long, non-motile	- numerous, true cilia
• goblet cells	- absent.	- present.
• pigment	- in sustentacular cells.	- absent.
• b.m.	- thin	- thick.
• Bowman's gl.	- present.	- absent.

Paranasal Sinuses

- Closed cavities in frontal, maxillary, ethmoid & sphenoid bones [around ^{nose} eye]
- lined e' resp. epith. w is thin e' few goblet cells.
- c.t. corium is thinner e' few mucous glands.

* Immotile Cilia Syndrome : $\rightarrow$ chronic sinusitis & bronchitis.

Nasopharynx

- Connects nose & oropharynx.
- lined w/ resp. epith = ps. strat. col. cil + goblet cells.
- c.t. core contains mucous gls. + pharyngeal tonsils
- have two openings of Eustachian tube (connect to middle ear)

The Larynx

- The Larynx
- Connects pharynx & trachea & 2 main functions:
 - production of sound
 - prevent food from entering trachea
 - Kept opened by Laryngeal Cartilages

Large: thyroid, cricoid & most of arytenoid = Hyaline Cartilage (may be calcified in old age)

Small: Epiglottis, corniculate, cuneiform tip of arytenoid = Elastic Cart. (not " " " ")

ligaments bind the cartilages

- lined e' resp. epith.: [ps. st. col. cil. e' goblet cells] except the vocal cords
- & lingual surface of epiglottis: lined e' st. sq. epith.

The Vocal Cords

- the upper pair = false (vestibular) folds:- covered e' resp. epith
 - prevent entrance of foreign bodies in larynx
- the lower pair = true cords:- covered e' non-kerat. st. sq. epith.
 - formed of elastic ligament + skeletal muscle
- the tension of vocal cords & the distance bet. them produce diff. sounds.

Trachea (12 cm)

Its wall is formed of 4 layers:

I. Mucosa:

1. respiratory epith: ps. str. col. cil. e' goblet cells
2. c.t. corium = lamina propria rich in bl. vs, ns & elastic fibres.
3. elastic memb = condensed elastic fs.

II. Submucosa:

loose c.t. containing bl. vs, nerves, lymph follicles + muco-serous glands.

III. Fibro-cartilagenous coat:

20 C-shaped plates of hyaline cartilage embedded in a dense fibrous c.t. They are completed posteriorly by: fibro. elastic memb (prevent overdistens) & smooth muscles called trachialis muscle to constrict the lumen & ↑↑ force of air flow during coughing & forced expiration.

IV. Adventitia: loose c.t.

Bronchial tree & lung

1. Extrapulmonary (1st) bronchus:

The trachea divides into 2 1st bronchi = have the same structure as trachea
1st bronchi penetrate the hilum → divide to give →

2. Intrapulmonary (2nd) bronchi: e' narrower lumen. The wall is formed of:

a. Mucosa:

- pseudo-str. col. cil e' less goblet cells.
- c.t. corium rich in elastic fibres + lymphocytes [MALT]
- No submucosa.

b. Musculosa: spirally arranged smooth muscles → shortening & ↓ diameter

c. Adventitia: c.t. rich in elastic fs. & contains: plates of hyaline cartilage, mucoserous glands & lymph follicles in bet.

3. Bronchioles: < 5 mm in diameter. Formed of:

- a. Mucosa: Simple col. cil. epith. e' **Clara** cells, scattered neuroendocrine cells + neuroepith. bodies (chemoreceptor for O₂ level)
- c.t. corium.

Clara Cells: - Dome shaped, cilia free cells.

- cytoplasm contains basal r-ER, apical s-ER & glycogen granules.

Functions: 1. secrete surfactant like material.

2. protect epith. by glycoptns. in their granules
3. protect against emphysema by opposing protease w' destroy wall of alveoli
4. protect " inhaled toxins by enzs. in s-ER.
5. may act as stem cells for other epith. cells.

b. Musculosa: circular smooth muscles: control air flow.

c. Adventitia: c.t. e' no cart., no glands & no lymph follicles.

	Extrapulm. bronchus	Intrapulm. bronchus
Lumen	- wider	- narrower
Mucosa	- less folded - ps. str. col. cil. e' many goblet cells - elastic memb. separates mucosa from submucosa	- more folded. - same e' less goblet cells - No elastic memb. but c.t. rich in elastic fs.
Submucosa	- present	- absent.
Cartilage	- C-shaped rings of hyaline cartilage.	- multiple plates.
Sm.ms	- bet. the ends of the cartilage	- spirally arranged.
Mucoserous gls.	- in submucosa	- in adventitia.
lymph follicles		

* **Bronchitis**: inflammation of mucosa of bronchi w are congested e' swollen mucous glands.

	Intra-pulm. bronchus	Bronchiole
lining Epith.	Pseudo-str. col. cil. e' goblet cells	S. col. cil. e' Clara Cells No goblet cells
Musculosa	spirally arranged sm.ms. (less developed)	- circularly arranged sm.ms. (more developed)
Adventitia	contains plates of cartilage - mucoserous glands - lymph nodules	- absent - absent - absent.

* **Bronchial asthma** = spasm of sm.ms of bronchioles → difficult expiration. Sympathomimetic drugs → bronchodilatation.

4. Terminal bronchiole:

similar to big bronchiole but the epith. is s. cub. cil. e' Clara cells.

The Respiratory Portion

the wall allows gaseous exchange.

1. Respiratory bronchiole:

transition zone bet. conducting & respiratory parts.

- lined e' s. cubical e' few cilia + Clara Cells.
- c.t. rich in elastic fibres.
- thin layer of smooth ms.
- Some alveoli open directly in its wall.

- smooth ms. are present only at these openings to control airflow.

3. Alveolar Sacs :

a group of adjacent alveoli $\bar{u}$ open in a common space e' no smooth ms. lined e' alv. epith.

4. Alveoli :

- the structural & functional unit of exchange of gases.
- Open in Resp. bronchioles, alv. ducts or alv. sacs.
- Separated by interalveolar septa & connected by alv. pores of Köhn.
- * Pores : equalize pressure bet. alveoli & provide collateral circ. of air in bronchiolar obstruction.
- lined e' alv. epith. e' 2 types of cells :

Type I pneumocytes [squamous alv. cells]

- the main cells lining the alveoli 97%
- Flat cells e' flat nuclei & short microvilli
- Have little cytoplasm e' few organelles around the nucleus + pinocytic vesicles (turn over of surfactant & removal of small particles from alv. surface).

Functions :

- ① Form a thin layer for exchange of gases.
 - ② Connected by tight junction to prevent entrance of tissue fluid to alveoli.
- * differentiated cells that cannot divide.

Type II = Great alv. cells = Secretory pneumocytes

- less numerous (3%)
- Cuboidal cells e' rounded Nuclei & short microvilli
- Abundant cytoplasm e' many mit., well developed G.A., r.ER, multilamellar bodies = (cytosomes) $\bar{u}$ contain surfactant. (start to appear in last weeks of gestation)

- ① Secrete Surfactant $\bar{u}$ line the alveoli
 - a. $\bar{u}$ surface tension to prevent collapse at the end of expiration.
 - b. has bactericidal effect.
- ② Stem Cells : give rise to type I & II pneumocytes.

(N.B.) In premature infants, surfactant is not enough $\rightarrow$ difficult expansion of alveoli $\bar{u}$ is called respiratory distress syndrome

Interalveolar Septa

Septa bet. alveoli rich in $\begin{cases} \text{bl. capillaries} \\ \text{extravasated WBCs e.g. monocytes} \rightarrow \text{alv. phagocytes} \end{cases}$
 the caps are supported by $\begin{cases} \text{elastic fs.} \rightarrow \text{allow expansion during inspiration} \\ \text{reticular fs.} \rightarrow \text{prevent overexpansion to protect delicate capillaries} \end{cases}$

* Emphysema :

permanent enlargement of alveoli due to destruction of elastic fibres in the interalveolar septa mainly due to cigarette smoking.

Blood Air (gas) Barrier : (0.1 → 1.5 μ m)

(7)

The barrier bet. bl. & alveolar air through w exchange of gases occurs :

formed of : 1. A layer of surfactant on alveolar epith.

2. Flat cells = type I pneumocytes (alveolar cells)

3. fused basement membs of type I pneumocytes & cap endothelium

4. endothelium of bl. capillaries.

Alveolar Phagocytes

def : phagocytic cells (macrophages) that pass through alveolar epith. to alveoli so, they are seen bulging from interalveolar wall or inside the alveoli

Origin : monocytes escaping from bl. capillaries. Stained e' : vital stain (Trypan blue)

types : 1. Dust cells :

= alv. phagocytes engulfing dust particles.

Fate : Coughed (expelled) e' sputum through resp. passages.

2. Heart failure Cells :

the pulm. capillaries are congested e' blood, capillaries rupture & RBCs escape to alveoli. alv. phagocytes phagocytose RBCs & acquire red

Colour due to hemosiderin granules inside their cytoplasm.

Fate : coughed e' sputum 2. pass e' lymph vessels. 3. remain in interalv. septa.

Pleura

Serous memb. formed of 2 layers : visceral L. covering the lung & parietal layer lining the thoracic wall. Both layers : lined e' s.s. mesothelium & c.t. rich in Tol. vs, ns, lymph vs & elastic fibres. They are separated by Serous fluid → lubrication & easy movement of lung & reduce friction bet. the lung & thoracic wall during respiration.

Foetal lung

- * thick c.t. septa → clear lobulation
- * Similar to a gland as the bronchial tree is similar to ducts & alveoli are similar to acini
- * Alveoli are collapsed & lined e' s. cubical epith.
- * Pulmonary vessels are congested e' blood.
- * It differs from a gland in $\left\{ \begin{array}{l} \text{bronchi \& bronchioles are folded.} \\ \text{presence of plate of cartilage around bronchi} \end{array} \right.$
- * The whole lung sinks in H₂O (medico-legal importance)

Structural Changes in the resp. airway :

(8)

1] Mucosa :

- Epith : gradual ↓↓ in thickness (ps.st.col.cil → s.col.cil → s.cub.cil → s.cub → alv.epith.)
- Cilia & Goblet cells : goblet cells are lost first. but cilia gradually ↓↓ to clean mucous.
- Lamina propria : ↓↓ in thickness & ↑↑ elastic fs.

2] Seromucous glands : ↓↓ in No. No glands in bronchioles.

3] Cartilage : in trachea → C-shaped rings. in bronchi → plates w gradually ↓↓ in size. in bronchioles → No Cartilage [sm.ms prevent collapse]

4] Smooth ms :

- prominent in the lower part of the conducting portion.
- less " " " resp. " - absent in alv. wall.
- • In trachea: trachialis ms. bet. ends of Cart. rings.
- In bronchi: spirally arranged.
- In bronchioles: continuous circular sm.ms.